NASA TECH BRIEF
Marshall Space Flight Center

A New Optical Recording Medium

The problem:

One of the next advances in computer capabilities, a step which has been just out of reach, is the development of an erasable, optical-recording material for computer memories. Such a development would permit the rapid, inexpensive storage and recall of entire pictures as a single unit. It would permit the analog storage of TV frames, printed pages, photographs and other visual information that must currently be stored as a sequence of ones and zeros.

Several optical storage candidates have been under consideration for some time. Among these is a lithium-rare earth crystal, lithium niobiate ($LiNbO_3$). Crystals of $LiNbO_3$ have several favorable properties for use as an optical recording medium. They have a high information capacity, a high readout efficiency, and are erasable. In addition, they require no chemical developing and can be used to store three-dimensional holograms. However, $LiNbO_3$ has one severe drawback; it is not sensitive enough to record at the rate required in computer processing.

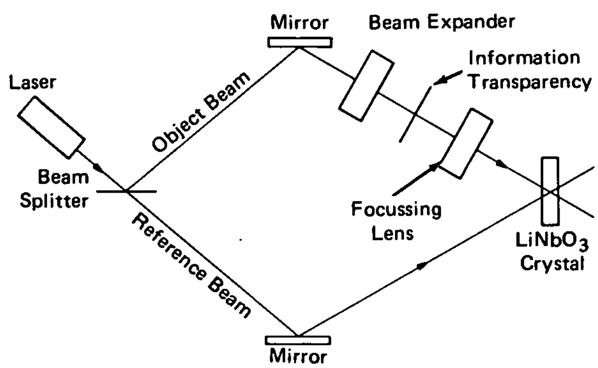
The solution:

For a time it had seemed as though work on a suitable optical recording medium had come to a standstill. Thin films, thermoplastics, and other alternatives to $LiNbO_3$ all had inherent limitations offering little hope for improvement. But it has recently been discovered that $LiNbO_3$ crystals can record data at a much higher rate when doped with transition metals.

How it's done:

If an $LiNbO_3$ crystal is doped during growth with a transition metal such as iron, copper, or manganese, the optical properties are significantly enhanced, and the crystal becomes a highly promising optical recording medium.

The crystals are doped with from 0.01 to 0.5 weight-percent of the transition metal. After growth, they are annealed, X-ray mounted, and sliced into 20 x 20 mm wafers one mm thick. Iron seems to be the best dopant. Iron-doped crystals will store a hologram image in as little as seven milliseconds using a commercial argon laser.



BLOCK DIAGRAM OF HOLOGRAPH arrangement used to record information in single crystal $LiNbO_3$. Readout is accomplished by blocking off the object beam and illuminating the hologram with the reference beam.

The recording process in $LiNbO_3$ is based on the electro-optic properties of the crystal. During crystal growth, the transition metal ions alter the optical absorption, electron concentrations, and trapping center concentrations. Electrons in the crystal are photo-excited when exposed to light. The spatial distribution of these excited electrons maps the intensity pattern of the incident light field. The photoexcited electrons drift out of the high intensity areas and are subsequently retrapped with an accumulation of electrons in regions of the crystal where the light intensity is less. The final result is a space charge pattern that is positive in regions of high optical intensity and negative in regions of low intensity. The space charge generates an electric field that locally modulates the index of refraction by the electro-optic effect.

(continued overleaf)

To store a hologram image in the crystal (see figure). light from an argon laser is split into two beams. One of the beams is modulated by the information transparency and focused to a 2-mm spot on the crystal. The second beam (the reference beam) intersects the signal beam at the crystal. The interference pattern of the two beams is recorded. The reference beam, by itself, is used to reproduce the original signal.

Another remarkable discovery is that the diffraction efficiency of the crystal can be increased by a factor of 2 to 5 when the same wavelength is used for readout as for storage. This discovery and the discovery of the transition metal enhancement effect may open up many new fields in optical recording, storage, and display. Large quantities of digital information may be stored and randomly accessed for an on-line optical memory in a computer complex. TV frames, printed matter, and other optical information may be stored and processed optically.

Note:

Requests for further information may be directed to:

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Patent status:

Inquiries concerning rights for the commercial use of this invention should be addressed to:

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Isomet Corp.
under contract to
Marshall Space Flight Center
(MFS-22348)